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Momcilovich et al.

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(54) **BATTERY OVERCHARGE MONITORING SYSTEM AND METHOD**

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(51) **Int. Cl.**

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B60L 3/00	(2006.01)
B60L 7/12	(2006.01)
B60L 11/14	(2006.01)
B60L 3/12	(2006.01)
B60L 11/12	(2006.01)

(52) **U.S. Cl.**

CPC ***H02J 7/0029*** (2013.01); ***B60L 3/0046*** (2013.01); ***B60L 3/12*** (2013.01); ***B60L 7/12*** (2013.01); ***B60L 11/123*** (2013.01); ***B60L 11/14*** (2013.01); ***B60L 11/1805*** (2013.01); ***B60L 11/1809*** (2013.01); ***B60L 11/1857*** (2013.01); ***B60L 11/1861*** (2013.01); ***B60L 11/1864*** (2013.01); ***H02J 7/0052*** (2013.01); *B60L 2240/421* (2013.01); *B60L 2240/423* (2013.01); *B60L 2240/441* (2013.01); *B60L 2240/443* (2013.01); *B60L 2240/545* (2013.01); *B60L 2240/547* (2013.01); *B60L 2240/549* (2013.01); *B60L 2240/80* (2013.01); *B60L 2250/10* (2013.01); *B60L 2250/16* (2013.01); *B60L 2260/44* (2013.01); *B60L 2260/54* (2013.01); *H02J 7/0031* (2013.01); *H02J 2007/0037* (2013.01); *Y02T 10/6217* (2013.01); *Y02T 10/642* (2013.01); *Y02T 10/7005* (2013.01); *Y02T 10/7044* (2013.01); *Y02T 10/7061* (2013.01); *Y02T 10/7077* (2013.01)

(58) **Field of Classification Search**

CPC B60L 11/1851; B60L 11/1611
USPC 320/109, 133, 137
See application file for complete search history.

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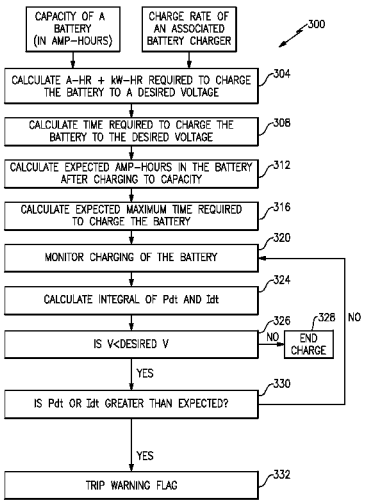
(57) **ABSTRACT**

An exemplary battery charge monitoring method includes, among other things, calculating expected charge data for a battery using at least a capacity of the battery and a charge rate, and comparing actual charge data to the expected charge data to identify differences between the actual charge data and the expected charge data.

17 Claims, 5 Drawing Sheets



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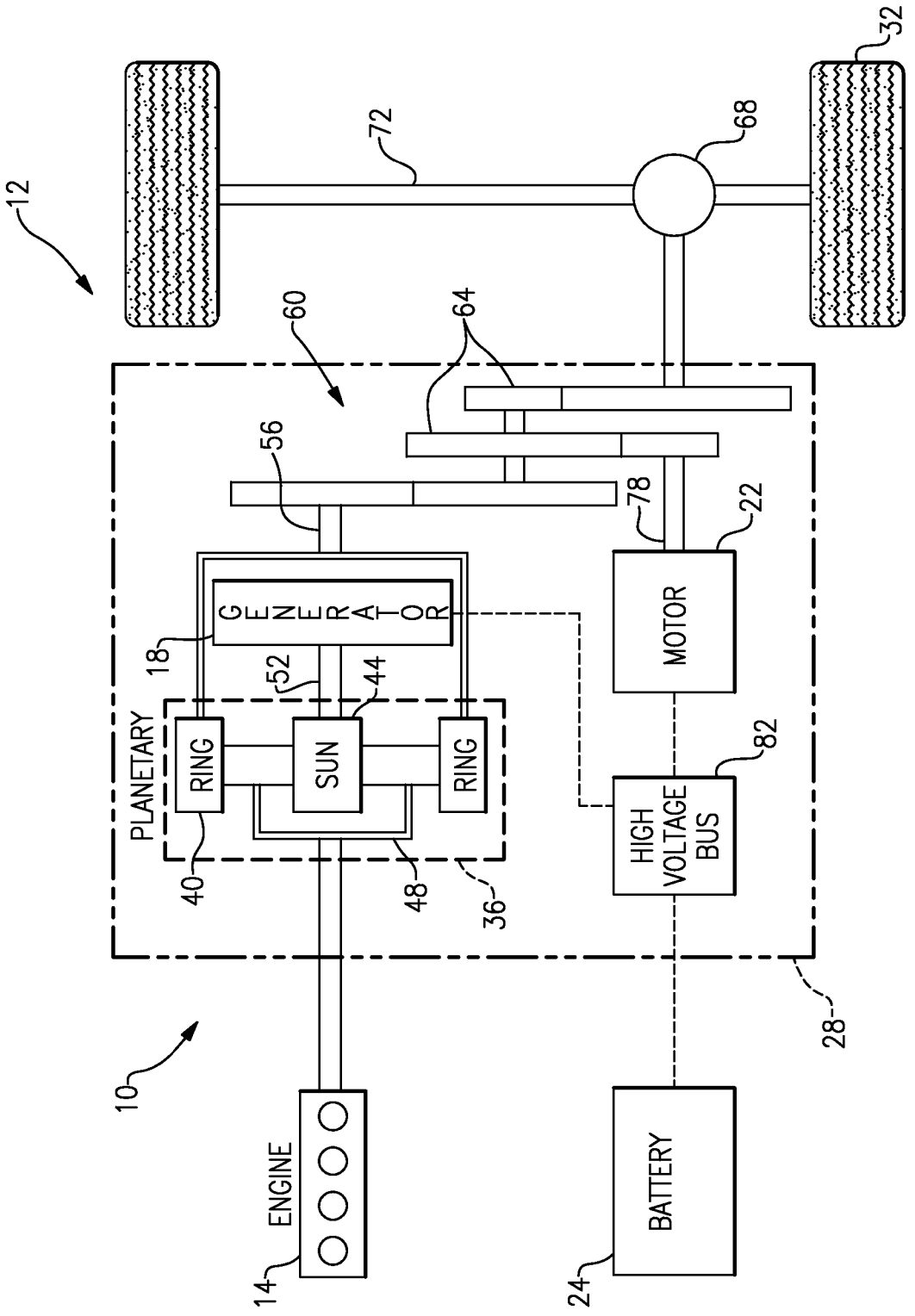
12
32
72
68
60
64
56
78
22
GENERATOR
MOTOR
18
52
44
PLANETARY
RING
SUN
RING
82
HIGH VOLTAGE BUS
40
48
36
28
10
ENGINE
14
BATTERY
24

FIG. 1

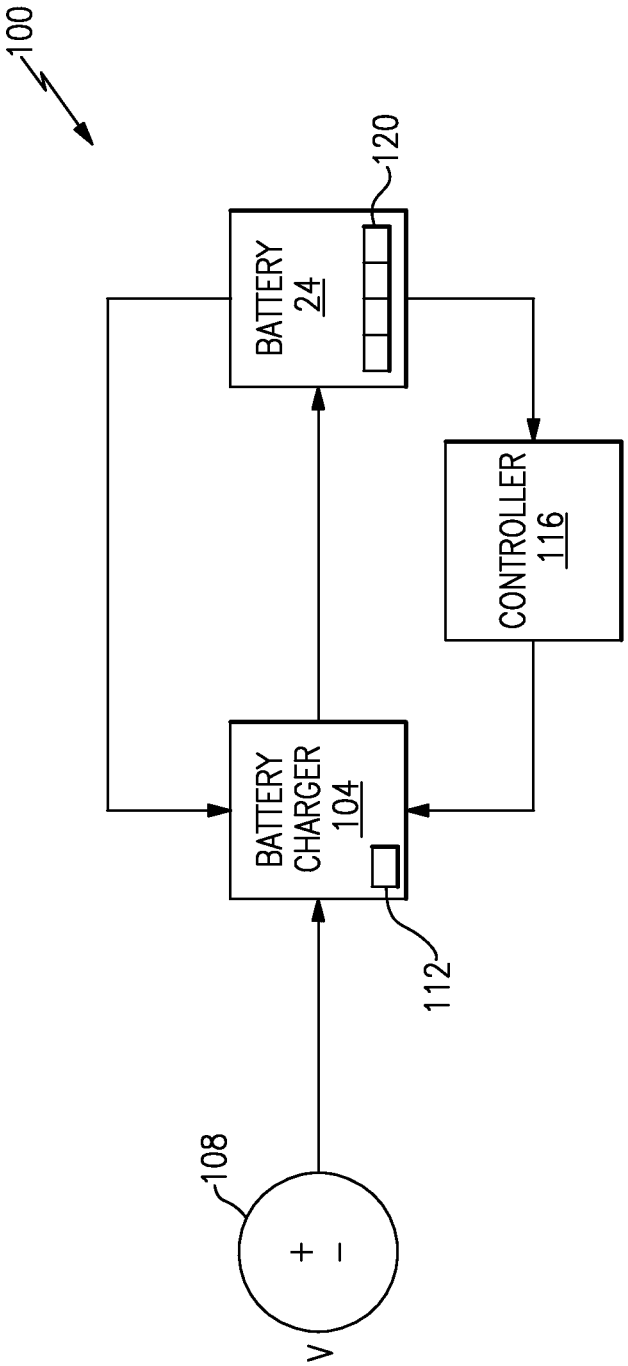
100
120
BATTERY
24
CONTROLLER
116
BATTERY
CHARGER
104
112
108
+
–
V

FIG.2

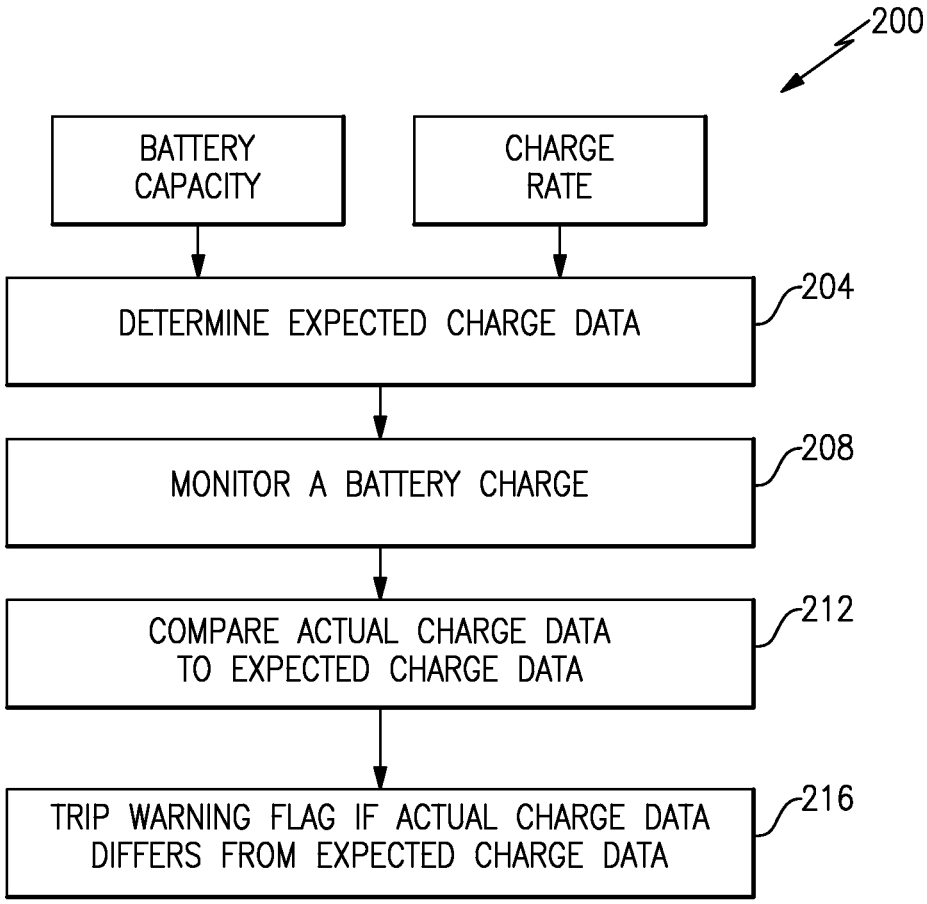
200
BATTERY CAPACITY
CHARGE RATE
DETERMINE EXPECTED CHARGE DATA
204
MONITOR A BATTERY CHARGE
208
COMPARE ACTUAL CHARGE DATA TO EXPECTED CHARGE DATA
212
TRIP WARNING FLAG IF ACTUAL CHARGE DATA DIFFERS FROM EXPECTED CHARGE DATA
216

FIG.3

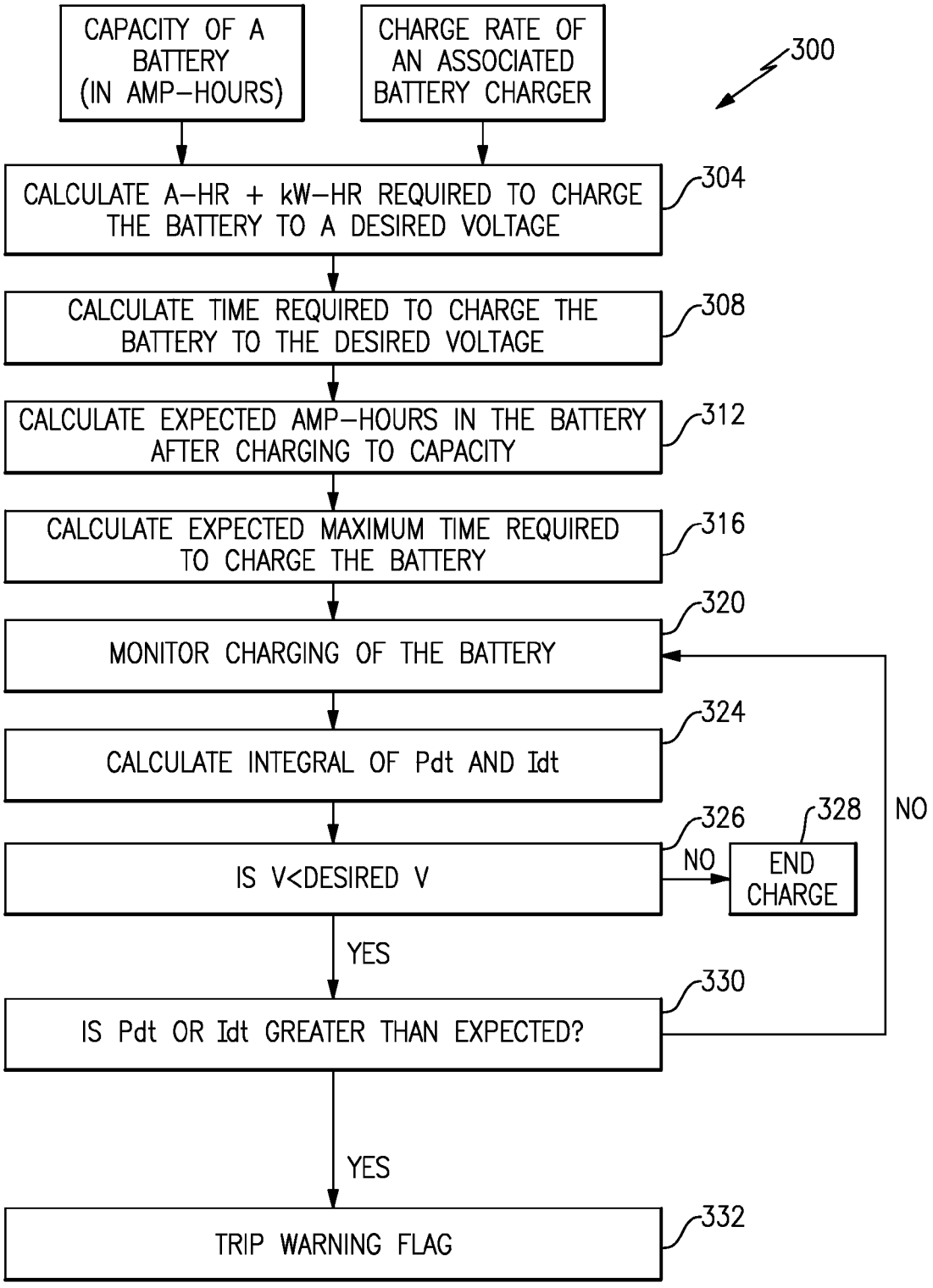
CAPACITY OF A BATTERY (IN AMP-HOURS)
CHARGE RATE OF AN ASSOCIATED BATTERY CHARGER
300
CALCULATE A-HR + kW-HR REQUIRED TO CHARGE THE BATTERY TO A DESIRED VOLTAGE
304
CALCULATE TIME REQUIRED TO CHARGE THE BATTERY TO THE DESIRED VOLTAGE
308
CALCULATE EXPECTED AMP-HOURS IN THE BATTERY AFTER CHARGING TO CAPACITY
312
CALCULATE EXPECTED MAXIMUM TIME REQUIRED TO CHARGE THE BATTERY
316
MONITOR CHARGING OF THE BATTERY
320
CALCULATE INTEGRAL OF Pdt AND Idt
324
IS V<DESIRED V
326
NO
END CHARGE
328
NO
YES
IS Pdt OR Idt GREATER THAN EXPECTED?
330
YES
TRIP WARNING FLAG
332

FIG.4

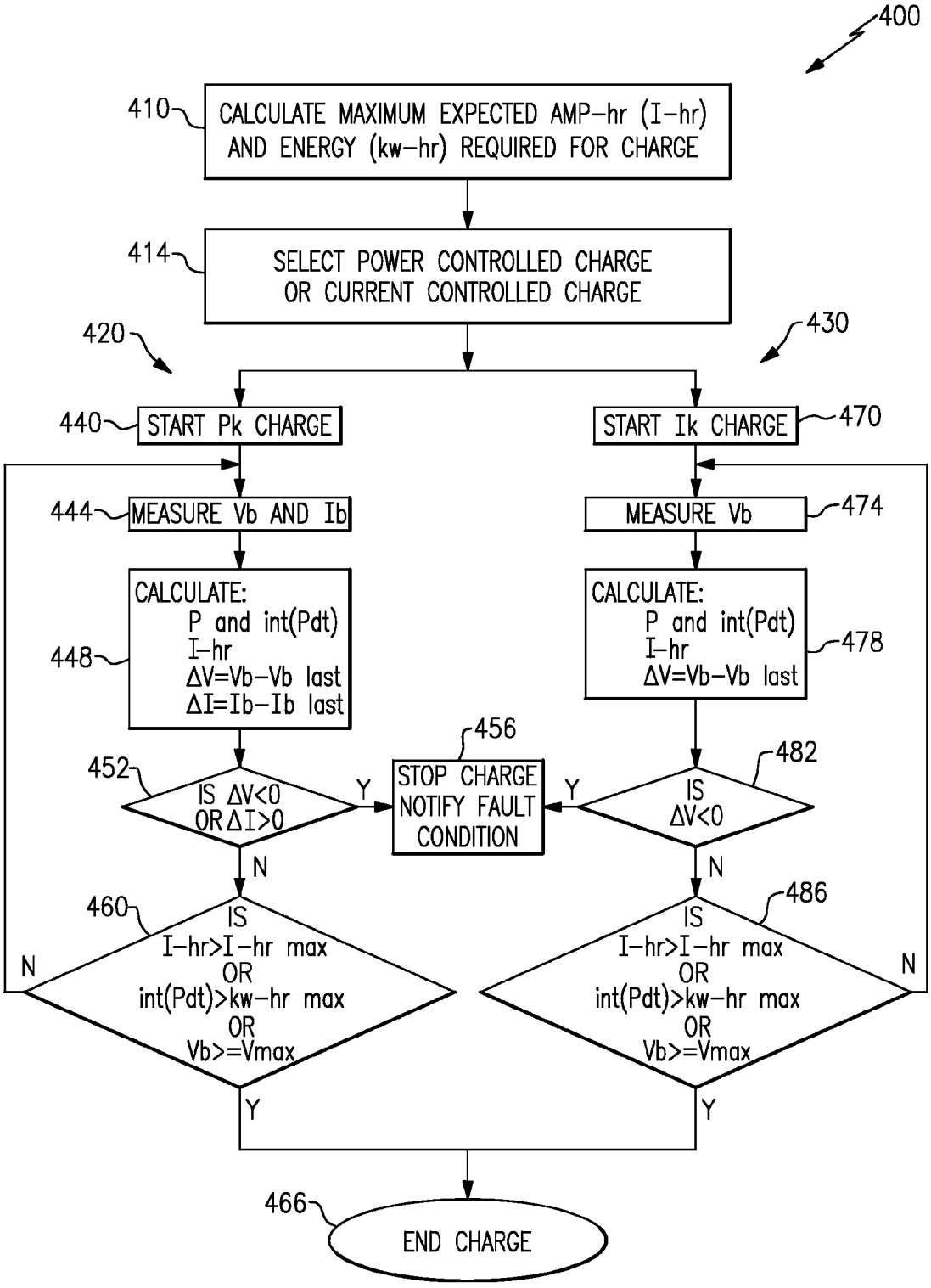
400
410
CALCULATE MAXIMUM EXPECTED AMP-hr (I-hr) AND ENERGY (kw-hr) REQUIRED FOR CHARGE
414
SELECT POWER CONTROLLED CHARGE OR CURRENT CONTROLLED CHARGE
420
430
440
START Pk CHARGE
470
START Ik CHARGE
444
MEASURE Vb AND Ib
474
MEASURE Vb
448
CALCULATE:
P and int(Pdt)
I-hr
ΔV=Vb-Vb last
ΔI=Ib-Ib last
478
CALCULATE:
P and int(Pdt)
I-hr
ΔV=Vb-Vb last
456
STOP CHARGE NOTIFY FAULT CONDITION
452
IS ΔV<0 OR ΔI>0
Y
482
IS ΔV<0
Y
N
N
460
IS I-hr>I-hr max OR int(Pdt)>kw-hr max OR Vb>=Vmax
N
486
IS I-hr>I-hr max OR int(Pdt)>kw-hr max OR Vb>=Vmax
N
Y
Y
466
END CHARGE

FIG.5

BATTERY OVERCHARGE MONITORING SYSTEM AND METHOD

TECHNICAL FIELD

This disclosure relates generally to charging a battery and, more particularly, to preventing overcharging of the battery.

BACKGROUND

Electric vehicles and many other devices may rely on a battery to store electrical power.

Generally, electric vehicles differ from conventional motor vehicles because electric vehicles selectively drive the vehicle using one or more battery-powered electric machines. Conventional motor vehicles, by contrast, rely exclusively on the internal combustion engine. Electric vehicles may use electric machines instead of, or in addition to, to the internal combustion engine. Example electric vehicles include hybrid electric vehicles (HEV's), plug in hybrid electric vehicles (PHEV's), and battery electric vehicles (BEV's).

Electric vehicles may be equipped with a battery configured to store electrical power for powering the electric machine. The batteries are charged prior to use, and recharged when the electric power in the battery becomes depleted.

A battery charger is typically used to charge batteries. In some electric vehicles, the electric machine may be used as a generator that is powered by the internal combustion engine in order to generate electrical power to charge the battery. Charging adds power to batteries. It can be difficult to determine when an appropriate amount of power has been added back to the battery during a charge. Adding too much power can cause the battery to become overcharged.

SUMMARY

A battery charge monitoring method according to an exemplary aspect of the present disclosure includes, among other things, calculating expected charge data for a battery using at least a capacity of the battery and a charge rate, and comparing actual charge data to the expected charge data to identify differences between the actual charge data and the expected charge data.

In a further non-limiting embodiment of the foregoing battery charge monitoring method, the method includes ending the charging in response to the comparing.

In a further non-limiting embodiment of any the foregoing battery charge monitoring methods, the expected charge data comprises an expected charge time, and the actual charge data comprises an actual charge time.

In a further non-limiting embodiment of any the foregoing battery charge monitoring methods, the method includes ending the charge in response to the expected charge time exceeding the actual charge time.

In a further non-limiting embodiment of any the foregoing battery charge monitoring methods, the expected charge data and the actual charge data comprise electric charge data, and charging of the battery is terminated in response to an actual amount of electrical charge exceeding an expected amount of electrical charge.

In a further non-limiting embodiment of any the foregoing battery charge monitoring methods, the expected charge data and the actual charge data comprise voltage data, and charging of the battery is terminated in response to an actual voltage exceeding an expected amount of voltage.

In a further non-limiting embodiment of any the foregoing battery charge monitoring methods, the expected charge data and the actual charge data comprise energy data, and charging of the battery is terminated in response to an actual energy to charge the battery exceeding an expected amount of energy required to charge the battery.

In a further non-limiting embodiment of any the foregoing battery charge monitoring methods, the expected charge data comprises a substantially monotonic increase of the voltage such that a change in the voltage during the charging is substantially non-negative, and charging is terminated if the change in the voltage is negative.

In a further non-limiting embodiment of any the foregoing battery charge monitoring methods, the expected charge data comprises a substantially monotonic decreasing battery current such that a change in the battery current during the charging is less than or equal to zero, and charging is terminated if the change in the current is greater than zero.

In a further non-limiting embodiment of any the foregoing battery charge monitoring methods, the capacity of the battery comprises a maximum voltage for cells of the battery.

In a further non-limiting embodiment of any the foregoing battery charge monitoring methods, the capacity of the battery comprises a percentage of a maximum voltage for cells of the battery.

In a further non-limiting embodiment of any the foregoing battery charge monitoring methods, the capacity of the battery comprises an amp-hour capacity for cells of the battery.

In a further non-limiting embodiment of any the foregoing battery charge monitoring methods, the method includes using a battery charge controller for the calculating and the comparing.

In a further non-limiting embodiment of any the foregoing battery charge monitoring methods, the battery is a vehicle battery.

A battery charging system according to an exemplary aspect of the present disclosure includes a battery charger to charge a battery; and a controller configured to selectively end a charge of the battery in response to a comparison of an expected charge amount to an actual charge amount, the expected charge amount calculated using at least a capacity of the battery and a charge rate.

In a further non-limiting embodiment of the forgoing battery charging system, the actual charge amount comprises a measurement of time spent charging the battery with the battery charger.

In a further non-limiting embodiment of any of the forgoing battery charging systems, the controller selectively ends the charge in response to the expected charge amount exceeding the actual charge amount.

In a further non-limiting embodiment of any of the forgoing battery charging systems, the battery is an electric vehicle battery.

DESCRIPTION OF THE FIGURES

The various features and advantages of the disclosed examples will become apparent to those skilled in the art from the detailed description. The figures that accompany the detailed description can be briefly described as follows:

FIG. **1** schematically illustrates an electric vehicle powertrain having a battery.

FIG. **2** schematically illustrates an example battery charging system for charging the battery of FIG. **1**.

FIG. **3** shows an example battery charge monitoring method.

FIG. **4** shows another example battery charge monitoring method.

FIG. **5** shows yet another example battery charge monitoring method.

DETAILED DESCRIPTION

FIG. **1** schematically illustrates a powertrain **10** for an electric vehicle **12**. Although depicted as a hybrid electric vehicle (HEV), it should be understood that the concepts described herein are not limited to HEV's and could extend to other electric vehicles, including but not limited to, plug-in hybrid electric vehicles (PHEV's) and battery electric vehicles (BEV's).

In one embodiment, the powertrain **10** is a powersplit powertrain system that employs a first drive system and a second drive system. The first drive system includes a combination of an engine **14** and a generator **18** (i.e., a first electric machine). The second drive system includes at least a motor **22** (i.e., a second electric machine), the generator **18**, and a battery **24**. In this example, the second drive system is considered an electric drive system **28** of the powertrain **10**. The first and second drive systems generate torque to drive one or more sets of vehicle drive wheels **32** of the electric vehicle **12**.

The engine **14**, which is an internal combustion engine in this example, and the generator **18** may be connected through a power transfer unit **36**, such as a planetary gear set. Of course, other types of power transfer units, including other gear sets and transmissions, may be used to connect the engine **14** to the generator **18**. In one non-limiting embodiment, the power transfer unit **36** is a planetary gear set that includes a ring gear **40**, a sun gear **44**, and a carrier assembly **48**.

The generator **18** may be driven by engine **14** through the power transfer unit **36** to convert kinetic energy to electrical energy. The generator **18** can alternatively function as a motor to convert electrical energy into kinetic energy, thereby outputting torque to a shaft **52** connected to the power transfer unit **36**. Because the generator **18** is operatively connected to the engine **14**, the speed of the engine **14** can be controlled by the generator **18**.

The ring gear **40** of the power transfer unit **36** may be connected to a shaft **56**, which is connected to vehicle drive wheels **32** through a second power transfer unit **60**. The second power transfer unit **60** may include a gear set having a plurality of gears **64**. Other power transfer units may also be suitable. The gears **64** transfer torque from the engine **14** to a differential **68** to ultimately provide traction to the vehicle drive wheels **32**. The differential **68** may include a plurality of gears that enable the transfer of torque to the vehicle drive wheels **32**. The second power transfer unit **60** is mechanically coupled to an axle **72** through the differential **68** to distribute torque to the vehicle drive wheels **32**.

The motor **22** (i.e., a second electric machine) can also be employed to drive the vehicle drive wheels **32** by outputting torque to a shaft **78** that is also connected to the second power transfer unit **60**. In one embodiment, the motor **22** and the generator **18** cooperate as part of a regenerative braking system in which both the motor **22** and the generator **18** can be employed as motors to output torque. For example, the motor **22** and the generator **18** can each output electrical power to a high voltage bus **82** and the battery **24**. The battery **24** may be a high voltage battery that is capable of outputting electrical power to operate the motor **22** and the generator **18**. Other types of energy storage devices and/or output devices can also be used with the electric vehicle **12**.

Referring now to FIG. **2** with continuing reference to FIG. **1**, a battery charging system **100** is used to recharge the battery **24** when charge in the battery **24** has been depleted due to operating the vehicle **12**. The battery charging system **100** could also be used to initially charge the battery **24** prior to use or prior to installation within the vehicle **12**. The battery **24** may stay in the vehicle **12** during a charge or may be removed from the vehicle.

The battery charging system **100** includes a battery charger **104** that selectively couples the battery **24** to a power source **108** to charge the battery **24** to a desired level. The battery charger **104** includes a processor **112** configured to control the selective coupling. The battery charging system **100** further includes a controller **116** configured to control the selective coupling to prevent overcharging the battery **24**. In this example, the processor **112** is part of the battery charger **104**. The controller **116** is a structure separate and distinct from the battery charger **104**.

When the battery charger **104** is coupled to the battery **24**, the battery charger **104** communicates charge to the battery **24** from the power source **108** to charge the battery **24** and specifically cells **120** of the battery **24**. Decoupling the battery charger **104** from the battery **24** ends the charge.

The battery charger **104** monitors the battery **24** to determine when to stop charging the battery **24**. Specifically, when the processor **112** determines that the battery **24** has received enough A-hr (Coulomb charge) and or kW-hr, the processor **112** stops the charge. The processor **112** selectively couples the battery charger **104** to the battery **24** to control charging of the battery **24**. The duration of the charge changes based on, an amount of charge required, a capacity of the battery **24**, a rate of charge, etc. In some examples, the processor **112** may incorrectly determine when to discontinue charging, which can result in undesirably charging the battery **24** beyond a desired level.

In this example, the controller **116** is used to inhibit charging the battery **24** beyond a desired level. The controller **116** monitors the charging of the battery **24** and compares expected charge data to actual charge data. The controller **116** may discontinue the charging, or take some other action in response to the comparison. For example, the controller **116** may discontinue the charging if the charging lasts longer than expected. Differences between expected charge data and actual charge data may, for example, indicate that the battery **24** requires repair or replacement.

Notably, in the example system **100**, both the controller **116** and the battery charger **104** (via the processor **112**) are calculating the charge status of the battery **24**. In some examples, the controller **116** prevents the battery **24** from becoming overcharged.

The example controller **116** is shown separate from the battery **24** and the battery charger **104**. The controller **116** may be positioned elsewhere within the system, such as attached to the battery **24** or within the battery charger **104**. The processor **112** could also be positioned outside the battery charger **104**.

Referring now to FIG. **3** with reference to FIG. **2**, an example battery charge monitoring method **200** identifies discrepancies between actual charge data and expected charge data. The method **200** is utilized by the controller **116** to determine when to charge, and when not to charge, the battery **24**.

Expected charge data may include an expected time to complete the charge, the expected A-hrs carried by the battery **24** after completing the charge, etc. An example discrepancy may be the actual charge time lasting longer than the expected charge time.

In the method **200**, a step **204** utilizes a battery capacity and a charge rate to determine expected charge data for the battery **24**.

The battery capacity, in this example, is a maximum total amount energy, A-hrs, or both that the battery **24** is capable of storing. The battery capacity may be based on design specifications for the vehicle **12** (FIG. **1**). In another example, the capacity of the battery **24** may be a desired percentage of the maximum total amount of battery capacity that the battery **24** is capable of storing. For example, it may be desirable to charge the battery **24** to ninety percent of its total battery capacity. In such an example, the battery capacity for the method **200** would be ninety percent of the total capacity of the battery **24**.

The charge rate is determined from the battery charger **104** and may utilize information from the battery **24**. The charge rate represents the rate at which the battery charger **104** delivers Amperes (A) or kW (kilowatts) from the power source **108** to the battery **24**.

After calculating the expected charge data at the step **204**, the method **200** begins monitoring a battery charge at a step **208**. This step monitors the A-hr and/or kW-hr charge rate to the battery **24** from the battery charger **104**. The monitoring may begin prior to, or at the same time as, the calculating step **204** in other examples.

At a step **212**, the controller **116** compares the actual charge data to the expected charge data from the step **204**. If the actual charge data is different than the expected charge data, the controller **116** responds, such as by tripping a warning flag at the step **216**. The controller **116** may also decouple the battery charger **104** from the battery **24** at the step **216**.

In one more specific example, the controller **116** compares the actual charge time to an expected charge time. If the actual charge time exceeds the expected charge time, the controller **116** initiates a flag that notifies a technician. This difference may indicate a failure within the system **100** or the vehicle **12**. An example failure may include degradation of the battery **24**. Severe degradation may require battery replacement.

Referring now to FIG. **4**, another example battery charge monitoring method **300** identifies discrepancies between actual A-hrs and expected A-hrs used to charge the battery **24** to a desired voltage. The method **300** also identifies discrepancies between actual time and expected time used to charge the battery **24** to the desired voltage.

In the method **300**, a calculation at a step **304** utilizes the capacity of the battery **24** and the charge rate associated with the battery charger **104** to determine the expected capacity of the battery when charging the battery **24** to a desired level. At a step **308**, the method **300** calculates the expected time required to charge the battery **24** to the desired voltage.

The capacity of the battery **24** in the example method **300** is a maximum total capacity that the battery **24** is capable of storing. The capacity may be based on design specifications for the vehicle **12** (FIG. **1**). In another example, the capacity of the battery may be a desired percentage of the maximum total capacity that the battery **24** is capable of storing. For example, it may be desirable to charge the battery to sixty percent of its maximum total capacity. In such an example, the battery capacity for the method **300** would be sixty percent of the total maximum capacity of the battery **24**.

Next, at a step **312**, the method **300** recognizes that the battery **24** may already have a partial charge and then calculates the expected total capacity that the battery will contain after charging the battery **24** to its capacity. The method **300** realizes that there may be some energy lost during charging, limitations in sensor capabilities, etc. and adds an incremental capacity to the expected charge capacity. The method **300** begins charging the battery at a step **316**.

The method **300** calculates integrals of Pdt (kW-hr) and Idt (A-hrs) at a step **324**. In this example, these calculations are running calculations that update in real-time during the charging. The voltage rise on the cells **120** (or open circuit voltage) of the battery **24** is a function of the integral of Pdt and Idt. The method **300**, at a step **326** determines if the voltage is greater than or equal to a desired voltage. If so, the method ends the charge at a step **328**.

At a step **330**, an actual kW-hr and an actual A-hrs from the step **324** are compared real time to the expected charge rate values from the steps **312** and **316**. If one of the actual values is greater than the expected values, the method **300** trips a warning flag at a step **332**. If neither of the actual values is greater than the expected values, the method **300** takes no action and the battery charger **104** continues to monitor charging of the battery **24**.

The warning flag at the step **338** may take many forms. The warning flag could, for example, be an internal alert that notifies a technician of a discrepancy between an expected Pdt and Idt and an actual Pdt and Idt.

If, during successive charges, the method **300** continues trip the warning flag, the method may initiate another type of warning, such as a visual warning that is visible to the driver. For example, if the battery is charged ten times and each of those charges results in the warning flag, the method **300** may initiate the visual warning.

Referring now to FIG. **5**, another example battery charge monitoring method **400** is used to charge a battery (or cells of the battery). Depending on the information discovered during the monitoring, the method **400** may notify a user of a fault condition associated with the battery when ending the charge. Alternatively, the method **400** may simply end the charge (without identifying any fault condition).

In this example, the method **400**, at a step **410**, calculates the expected amp-hours (I-hr max) and energy (in kW-hrs) that are required to charge the battery. Factors that may be used to calculate these expected values include the battery's state-of-charge, capacity, temperature, age, maximum voltage, resistance, etc. Another factor may be a particular charge strategy for the battery.

The battery (and cells of the battery) typically have a known input resistance R. If the input resistance is not known, a person having skill in this art and the benefit of this disclosure would be able to determine the resistance R.

After calculating the expected values at the step **410**, the method **400** proceeds down a first path **420** or a second path **430**. The first path **420** is utilizes constant power charging (Pk) to charge the battery. The alternative second path **430** utilizes constant current charging (Ik) to charge the battery. A step **414** represents this selection. A user may make the selection at step **414** in some examples.

Referring to the first path **420**, the charge starts at a step **440**. The actual battery voltage (Vb) and actual battery current (Ib) are then monitored at a step **444** during the charge. With these actual values, the method **400** calculates actual power (P), actual energy (int(Pdt)), Amp-hr (int(Idt)), delta V, and delta I at a step **448**. As may be appreciated, energy (kW-hr) can be represented as int(V*Idt), and Amp-hr as int(Idt).

In this example, the increasing charge of the battery causes its voltage to increase monotonically, such that delta V is non-negative. Since a relatively constant power charge is utilized, and, because P=V*I, the voltage increasing monotonically indicates that the current during the charge decreases monotonically, such that delta I is less than or equal to zero.

Fluctuations from a substantially monotonic increase of the voltage, a substantially monotonic decrease of the current, or both are then detected at a step **452**. During the charging, if

the actual voltage is decreasing or the actual current is increasing, there is an assumed error associated with the battery. The charge is then stopped, and an operator is notified of a fault condition at a step **456**.

If there are no such fluctuations, the method **400** proceeds to a step **460**. At the step **460**, if the actual battery voltage is greater than or equal to an expected voltage max, the charge is stopped at a step **466**. Also, at the step **460**, if the actual A-hr is greater than A-hr max similar to FIG. **4** step **316**, the charge is stopped at the step **466**. Further, at the step **460**, if the energy to the battery (kW-hr–I^2R loss) is greater than an estimated energy value required by the battery, the method **400** stops the charge at the step **466**.

Referring to the current controlled charge-based second path **430**, the charge starts at a step **470**. The actual battery voltage is then monitored at a step **474**. Ib is known, as the second path **430** represents current controlled charge. With the monitored value from the step **474**, the method **400** calculates power (P), energy (int(Pdt)), A-hr (int(Idt)), and delta V at a step **478**.

Since the example battery is charged at a relatively constant current, the voltage should always be increasing. If delta V is less than zero, which is detected at a step **482**, the method **400** assumes there is some error associated with the battery. The charge is then stopped, at the step **456**, and an operator is notified of a fault condition.

If delta V is greater than or equal to zero, the method **400** proceeds to a step **486**. At the step **486**, the method **400** determines if the voltage used for the charge is greater than or equal to an expected voltage max. If so, the charge ends at the step **466**. Also, at the step **486**, if the actual A-hr is greater than an expected A-hr, or if the energy to the battery (kW-hr–I^2R loss) is greater than an estimated energy value required by the battery, the method **400** ends the charge at the step **466**.

In the some examples of this disclosure, charging may be automatically terminated in response to comparisons of actual measured data to expected (or calculated) data. In one more-specific example, actual Amp-hours required to charge exceeding calculated Amp-hours required to charge automatically terminates the charging. In another example, actual energy delivered to the cell exceeding calculated energy needed automatically terminates the charging. In other example, the charging is terminated if delta V of the battery is less than zero for power controlled or current controlled charges. In yet another example, the charging is terminated if delta I of the battery is positive for power controlled charges. Charging may also be terminated if the voltage of the battery is greater than a calculated maximum voltage for the battery.

A feature of this disclosure is real time monitoring of the battery for faults, plus determining a natural end of charge that may be based on maximum voltages, amp-hour maximums, and kilowatt-hour maximums.

Although the different non-limiting embodiments are illustrated as having specific components or steps, the embodiments of this disclosure are not limited to those particular combinations. It is possible to use some of the components or features from any of the non-limiting embodiments in combination with features or components from any of the other non-limiting embodiments. Further, unless otherwise specified, the steps may be performed in any order.

The preceding description is exemplary rather than limiting in nature. Variations and modifications to the disclosed examples may become apparent to those skilled in the art that do not necessarily depart from the essence of this disclosure. Thus, the scope of legal protection given to this disclosure can only be determined by studying the following claims.

We claim:

1. A battery charge monitoring method, comprising:

calculating expected charge data for charging of a vehicle battery using at least a capacity of the vehicle battery, a charge rate, and an expected charge time;

during the charging, using a controller to compare actual charge data to the expected charge data to identify at least one difference between an actual charge time and the expected charge time, and at least one difference between an actual amount of energy used to charge the vehicle battery and an expected amount of energy required to charge the battery; and

ending the charging in response to the actual amount of energy to charge the vehicle battery exceeding the expected amount of energy required to charge the vehicle battery.

2. The battery charge monitoring method of claim **1**, further comprising ending the charging in response to the expected charge time exceeding the actual charge time.

3. The battery charge monitoring method of claim **1**, wherein the expected charge data and the actual charge data comprise electric charge data, and charging of the vehicle battery is terminated in response to an actual amount of electrical charge exceeding an expected amount of electrical charge.

4. The battery charge monitoring method of claim **1**, wherein the expected charge data and the actual charge data comprise voltage data, and charging of the vehicle battery is terminated in response to an actual voltage exceeding an expected amount of voltage.

5. The battery charge monitoring method of claim **1**, wherein the expected charge data comprises a substantially monotonic increase of the voltage such that a change in the voltage during the charging is substantially non-negative, and charging is terminated if the change in the voltage is negative.

6. The battery charge monitoring method of claim **1**, wherein the expected charge data comprises a substantially monotonic decreasing battery current such that a change in the vehicle battery current during the charging is less than or equal to zero, and charging is terminated if the change in the current is greater than zero.

7. The battery charge monitoring method of claim **1**, wherein the capacity of the vehicle battery comprises a maximum voltage for cells of the vehicle battery.

8. The battery charge monitoring method of claim **1**, wherein the capacity of the vehicle battery comprises a percentage of a maximum voltage for cells of the vehicle battery.

9. The battery charge monitoring method of claim **1**, wherein the capacity of the vehicle battery comprises an amp-hour capacity for cells of the vehicle battery.

10. The battery charge monitoring method of claim **1**, further comprising using a battery charge controller for the calculating and the comparing.

11. The battery charge monitoring method of claim **1**, wherein the calculating is prior to the charging.

12. The battery charge monitoring method of claim **1**, wherein the vehicle battery is a traction battery, and further comprising powering an electric machine with power from the traction battery to generate torque to drive at least one set of vehicle drive wheels.

13. The battery charge monitoring method of claim **1**, further comprising calculating using the controller and charging using a battery charger, the controller separate and distinct from the battery charger.

14. The battery charge monitoring method of claim **1**, further comprising charging the battery using a constant power level in response to a first input from a user and charg-

ing the battery using a constant current level in response to a different, second input from the user.

15. A battery charging system, comprising:

a battery charger to charge a vehicle battery; and

a controller configured to selectively end a charge of the vehicle battery in response to an actual charge amount exceeding an expected charge amount, the expected charge amount calculated using at least a capacity of the vehicle battery and a charge rate, the expected charge amount including an expected amount of electrical charge used to charge the vehicle battery.

16. A battery charge monitoring method, comprising:

Comparing, using a controller, an actual charge time for a charge of a vehicle battery to an expected charge time for the charge of the vehicle battery;

comparing an actual amount of charge used to charge the vehicle battery to an expected amount of charge used to charge the vehicle battery;

ending the charge for the vehicle battery in response to a difference between the actual charge time and the expected charge time; and

ending the charge of the vehicle battery in response to a difference between the actual amount of charge and the expected amount of charge.

17. The method of claim **16**, further comprising ending the charge of the vehicle battery in response to the actual charge time exceeding the expected charge time.

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